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ABSTRACT

This report describes the multifaceted Math/Science Education Program for Women at the Lawrence Hall of Science aimed at attracting and retaining women and minorities in math and science. The inservice teacher education program (EQUALS) focuses on methods/materials to attract women and minority students in mathematics. Evaluation of the program indicates an increase in the number of women in advanced math classes and all students of EQUALS teachers improving attitudes toward the study of math and an increasing interest in learning more about math-related careers. Students of SPACES (Solving Problems of Access to Careers in Engineering and Science), consisting of 34 classroom activities, showed significant increases in knowledge of and interest in scientific careers and in spatial visualization and problem-solving skills in math. MATH FOR GIRLS (ages 6-12) involves hands-on experiences in logical thinking and problem-solving skills in mathematics; enrollment of females in all Lawrence Hall classes has increased 13 percent over a 7-year period. FAMILY MATH focuses on improving the skills of minority parents to enable them to help their children improve performance. Also described are activities of the MATH/SCIENCE NETWORK, an association of scientists, engineers, educators, and parents working to promote participation of women in math and science. (JN)

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THE MATH AND SCIENCE EDUCATION OF WOMEN AND MINORITIES: THE CALIFORNIA PERSPECTIVE*

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The Problem

One of the issues that has concerned educators, parents, industry and the business and scientific community in the last decade has been the shrinking pool from which we are drawing our scientific and technical workforce. Nationally, we face shortages of computer professionals, engineers, and technicians, while students are graduating from high school with inadequate math, science, and computer skills to enter these fields of study and work. A recent national study reported that ". . . more students than ever before are dropping out of science and mathematics courses after the tenth grade, and this trend shows no signs of abating . . ." (National Science Foundation and Department of Education, 1980). Further, only one-third of the school districts in the United States require more than one year of mathematics and science in grades nine through twelve (Weiss, 1978).

The American Electronics Association reports that ". . . lack of emphasis of high school math and science . . . is a major cause of the technical manpower shortage; high school students who lack basic math through algebra find themselves as college students choosing against technical careers . . . The increasing technological complexity of the

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workplace is creating a need for high school preparation in physics and chemistry--both of which first require competency in algebra . . . ." (Hubbard, 1980).

A New Pool

In California, these shortages are critical since our economy is tied to our high technology industries. Yet, California youngsters lag behind the national average in the number of years of mathematics they study in high school (Brown, 1981).

The traditional pool of white males from which we have drawn our scientists, engineers, technicians, and apprentices in the past is simply not sufficient to meet our current and future needs for professional and skilled workers. We must seek to enlarge that pool--not only to meet employment needs but to prepare a larger number of our students for the mathematical, scientific, and technical literacy that will be required of them in future years.

Our most promising source of future scientific and technical talent are women and minorities, who make up 60% of our population. In 1980, women were only four percent of the engineering workforce and racial minorities comprised only six percent of all employed engineers. Of the one million college-bound students taking the SAT's last year, two-thirds of the males, but only one-half of the females had taken four or more years of high school mathematics. Clearly, this underrepresented population can and should be encouraged to increase their participation in math and science and to further enlarge the creative pool from which we draw our scientific and technical brainpower.

Why women and minorities avoid math and science has been the object of a number of studies in the last decade (Fox, 1977). Three common findings appear to emerge from these studies:

1. Enrollment in elective mathematics courses appears to be closely related to students' perception of the usefulness of math to their future lives.

2. Enrollment in elective mathematics is strongly correlated to students' estimation of their ability to be successful in mathematics courses.

3. The attitudes of parents, teachers, and peers exert an important influence on students' decisions to continue in math and science courses once they become optional.

Promising Solutions

Knowing this, it is then possible to develop programs, materials, and instructional strategies aimed at attracting and retaining women and minorities in math and science. To be effective, these approaches should be directed toward several target groups and employ the resources of a variety of individuals and organizations.

The Math and Science Education Program for Women at the Lawrence Hall of Science, which I direct, is one example of a multifacted approach. The program encompasses teacher education (EQUALS), curriculum development (SPACES), direct services to students (MATH FOR GIRLS), parent education (FAMILY MATH), community service (MATH/SCIENCE NETWORK) and publications.

EQUALS is an inservice program for teachers, counselors, and administrators, serving grades K-12 and focusing on methods and materials to attract and retain women and minority students in mathematics. Since 1977,

1,500 California educators have participated in 10- to 30-hour inservices at the Lawrence Hall or in their school districts; another 2,000 educators in Arizona, Colorado, Idaho, Iowa, Kansas, Maine, Maryland, Montana, Nebraska, Nevada, New Mexico, Oregon, Pennsylvania, Vermont, Washington, and Wyoming have attended inservices conducted by EQUALS staff, and 30 inservice trainers from 25 additional states have participated in staff development at Berkeley prior to implementing EQUALS in their states.

The program has been extensively evaluated. Data demonstrate that schools in which the program has been working for two or more years are showing a slow but steady increase in the number of women students in advanced mathematics classes; and all students of EQUALS teachers have an improved attitude toward the study of mathematics and an increased interest in learning more about math-related occupations. The program is funded by the U.S. Department of Education, the National Science Foundation, the Carnegie Corporation of New York, and the University of California.

SPACES (Solving Problems of Access to Careers in Engineering and Science) is a National Science Foundation-funded curriculum project that consists of 34 classroom activities in mathematics and career education designed to increase students' understanding of the relationship of problem solving to scientific activity. The materials were tested in nine California sites in 3rd- through 10th-grade math classes. Matched pretest and posttest data were available for 518 students who had received instruction in a sample of five activities and for 467 students from the same school, grade level, and academic track who had not received the materials. SPACES students showed significant increases in their knowledge of and interest in scientific careers and in their spatial visualization and problem-solving skills in mathematics. SPACES is now in press and will be available late Spring.

MATH FOR GIRLS is an on-going Lawrence Hall of Science course to involve 6- to 12-year-old girls in "hands-on" experiences in logical thinking and problem solving that stimulate their curiosity and interest in mathematics. Initiated as a way to increase female participation in the Hall's after-school program, MATH FOR GIRLS has served 1,000 students and the percentage of females in all Hall classes has increased from less than 25% in 1973 to 38% in 1980. A course curriculum is available (Math for Girls and Other Problem Solvers). The program is self-supporting through tuition fees.

FAMILY MATH addresses the problems of poor preparation, performance, and participation of women and minorities in mathematics. Funded by the U.S. Department of Education, (FIPSE), this first year (of a three-year program) is concentrating on working with parents and children in a predominantly minority community in the San Francisco Bay Area to improve basic math skills of parents, help them to assist their children in learning mathematics, and provide both parents and children with an opportunity to meet minority and women role models from the community who are working in scientific and technical occupations.

The MATH/SCIENCE NETWORK is an association of 1,000 scientists, engineers, educators, and parents who have been working cooperatively in the San Francisco Bay Area since 1976 to promote the participation of women in mathematics and science-related fields. Established originally as a volunteer organization, the Network has received funds from the Carnegie Corporation of New York, the Department of Education, the National Science Foundation, and numerous local industries to sustain and expand its work. Among its activities, the Network sponsors day-long conferences on college and university campuses to introduce

7th- through 12th-grade young women to "role models" (women working in scientific and technical fields) and to hands-on workshops in math and science that motivate and challenge students. On March 20, 1982, 23 such conferences were held in California, 17 in 9 other states, and 3 in Australia. We reached, this one day, 14,000 students and 5,000 women scientists, engineers, apprentices, parents, and teachers with the message that math and science are exciting and appropriate fields for women.

The Future

The programs I've described are promising solutions; much, of course, remains to be done. The major components of change needed to increase significantly the participation of women and minorities in mathematics and science over the next decade are: teacher preparation; curriculum improvement; increased course requirements; and industry-education linkages. All are essential to the success of this endeavor. Let me take each in its turn.

Teacher preparation: As mathematics teachers are lost to industry or retirement, they are being replaced by teachers who have little or no formal training in mathematics. At the same time, the traditional support systems that have helped teachers gain competencies in new subject areas are being withdrawn. Federal and state cutbacks are eliminating most of the resources for the retraining of teachers. Rather than cutbacks, what is desperately needed at this time is a recommitment to teacher training. New courses focusing on mathematical literacy need to be developed to help teachers acquire an overview and familiarity with mathematical topics. In-depth work is needed on the

teaching of problem solving, the use of manipulative materials to teach abstract concepts, and in small-group teaching and learning strategies. These courses should be included in preservice education programs as well.

Curriculum improvement: New courses are needed. The traditional junior high shop course, for example, might be replaced by an introduction to technology, helping students learn how things work and to explore various technological systems through "hands-on" activities such as building a circuit board or a solar panel. Girls, in particular, would benefit from such courses.

Increased course requirements: It will be necessary to increase the mathematics and science requirements for high school graduation if students are to achieve mathematical and technical literacy. Without the necessary teacher preparation and curriculum improvements, however, increased enrollments will not by themselves improve literacy.

Industry-education linkages: Sustained cooperation between industry and the schools is necessary to develop a pool of skilled workers. There are excellent opportunities for industry-school collaborations in the development of new curricula and teacher preparation, but it must be a two-way street. Industry needs to become more informed about effective programs already in the schools and encouraged to support them. And educators need to find out more about the job requirements and attitudes that contribute to employee success in different industries so that they can better prepare their students.

"Research-in-Industry" projects could be arranged for high school counselors. During brief leaves of absence, counselors could rotate among several industries, collecting information about job needs, requirements for advancement in an industry, formal and informal methods of recruiting and promoting employees, and the skills and attitudes that

contribute to success in particular organizations. Counselors could then compile what they have learned, for use by secondary students, parents, and teachers.

In addition, mobile vans might travel to elementary and secondary schools offering "hands-on" prevocational courses with tools and equipment not normally available in schools. Both boys and girls could thus have a chance to learn mechanical skills and understand how they are used.

Both industry and education should benefit from such collaborations. Employers hiring in the mathematical, scientific, technical, and trades fields would enlarge their pool of eligible workers. Educators would learn about skills needed in a variety of occupations. The programs could lead to more responsive curricula, with one consequence being the much better preparation of young women and minorities for entering the scientific and technical workforce.

These are only a few suggestions about what needs to be done, but we are at a critical juncture. With federal cutbacks, we look to the State and local resources to pick up the focus and planning that agencies such as the National Science Foundation have pioneered in the development of programs to increase the numbers of women and minority scientists and engineers. While a few programs may be completely financed by the private sector, and some may obtain multiple sources of funding, the majority of programs that address teacher training, student learning, curriculum improvement, and dissemination of effective practices in the education of women and minorities will not be sustained or created without State support.

It will take both a national and state commitment to make quality

math and science education a priority in California. To do this, we will need a concerted and coordinated effort to ensure that all California schools have equal access to successful programs. This can be accomplished, first by informing educators that such programs exist; second, by providing resources for the schools to obtain and adapt these models; and third, by awarding seed money for promising approaches to increasing the participation of women and minorities in math and science.

If these tasks can be carried forth, we will see significant improvements in California's math and science education in the eighties.

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